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Recognition memory with little or no remembering: Implications for a detection model

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Remembering and knowing are two states of awareness that reflect autonoetic and noetic consciousness. Recent extensions of signal detection theory have attempted to fit *remember* and *know* responses, which measure these states of awareness, to a continuum of trace strength or familiarity. The model assumes there are two response criteria, a remembering criterion, which is more strict, and a recognition criterion, which is more lenient and leads to any positive recognition response. The most important prediction of this model is that bias-free estimates of memory should be the same whether derived from overall hit and false alarm rates or from *remember* hit and false alarm rates. We describe evidence that disconfirms this prediction and discuss other findings that the model cannot accommodate.

Remember and *know* responses are subjective reports of remembering and knowing, which are two states of awareness that reflect autonoetic and noetic consciousness, respectively (Tulving, 1985). Autonoetic consciousness is the ability to travel mentally in time, and to re-experience previous experiences (or imagine future experiences) that are associated with events that are personal and at which one is present (Wheeler, Stuss, & Tulving, 1997). Noetic consciousness is the ability to become aware of knowledge in the absence of any such self-involvement. This awareness may also relate to personal events, but knowing about such events does not entail experiencing them personally in the sense that remembering does. Tulving identified these two kinds of consciousness with episodic and semantic memory systems.

Remembering and knowing have also been related to processing models of memory, for example, the dual-process model of recognition memory in Jacoby's (1991) process dissociation procedure, which distinguishes between a controlled recollection process and an automatic familiarity process (see, e.g., Jacoby, Yonelinas, & Jennings, 1997). And in another processing model, an extension of the transfer-appropriate processing approach, remembering has been shown to be dependent on either conceptual or perceptual distinctiveness, whereas knowing is related to processing fluency (Rajaram, 1996, in press).

These theories are supported by a great many studies that converge on the conclusion that remembering and knowing are affected differently, and in quite systematic ways, by different variables (for reviews, see Gardiner & Java, 1993; Rajaram & Roediger, 1997; Richardson-Klavehn, Gardiner, & Java, 1996). Indeed, it has now been shown that remembering and knowing are fully independent functionally, in the sense that there are not only variables that affect remembering and not knowing, or knowing and not remembering, but also variables that have opposite effects on remembering and knowing, and variables that have similar effects on remembering and knowing (see Gardiner, Kaminska, Dixon, & Java, 1996).

Previous interpretations of remembering and knowing have recently been challenged by revivals of the signal detection model (Donaldson, 1996; Hirshman & Master, 1997; Inoue & Bellezza, in press). The thrust of this challenge is that it may be possible to account for remembering and knowing by a unitary trace strength model, according to which *remember* and *know* responses merely reflect relatively strong and relatively weak memory traces, rather than different memory systems or different kinds of processes.

In its revived form, this model assumes that a continuum of information of varying familiarity or trace strength is associated with two response criteria, a remembering criterion, which is more strict, and a recognition criterion, which is more lenient, and which includes *know* responses. Donaldson (1996; see also Donaldson, MacKenzie, & Underhill, 1996) and Hirshman and Master (1997) have shown mathematically that these criteria can

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be placed in ways that mimic the kinds of dissociation and association that have been observed empirically in recognition memory studies of remembering and knowing. However, the model does not provide any more detailed explanation as to why the criteria are affected systematically by the different variables that are presumed to influence them, or as to how criteria placed on a continuum of trace strength might give rise to qualitatively distinct states of awareness. Hence the value of the model depends largely on its predictive power.

The most important prediction the model makes is that estimates of memory that are theoretically bias free should be the same whether derived only from *remember* hit and false alarm rates or from overall hit and false alarm rates. In a meta-analysis of 80 different conditions in 28 experiments from 17 articles, Donaldson (1996) showed that A' estimates of discriminability were only marginally greater when derived from overall hit and false alarm rates than when derived from *remember* hit and false alarm rates, though a different outcome was obtained when d' estimates were calculated. However, Donaldson (1996) argued that although d' tends to be a slightly better measure when performance is unbiased, A' is more appropriate when there are criterion differences, and such differences are of course predicted in his detection model (see also Donaldson, 1993).

In fact, although the A' estimates in Donaldson's (1996) meta-analysis differed only marginally, the difference was very consistent. Of the experimental conditions that showed a difference, the A' estimates derived from overall hit and false alarm rates were greater than those derived from *remember* hit and false alarm rates in 60 out of 72 cases. Using a normal approximation to the binomial for carrying out a sign test, this trend gives a z score of 5.54. Thus the appropriate conclusion from the meta-analysis would seem to be that discriminability is significantly greater when estimated from overall recognition than when estimated from remembering.

The database presented by Donaldson (1996) has since been updated and now includes 182 different conditions (Donaldson, personal communication, April 11, 1997). Of the experimental conditions that show a difference in this database, the A' estimates derived from overall hit and false alarm rates are greater than those derived from *remember* hit and false alarm rates in 127 out of 162 cases, a trend that yields an even higher z score of 7.15. Once again, though, d' estimates did not show this trend and were not reliably different. This discrepancy between the two kinds of estimate is somewhat puzzling, but may reflect the fact that A' is more resistant to criterion differences than d', or the influence of the underlying distributions and the assumptions made about them (see Donaldson, 1993; Macmillan & Creelman, 1996, for more discussion).

The main purpose of this article is to report similar findings in individual subject data. The initial findings are taken from one of a number of published articles that were omitted from Donaldson's (1996) original meta-analysis, and we report three further replications of them. In all four cases, the findings are taken from one set of conditions in experiments that involved a number of other conditions. These experiments were concerned with theoretical issues that are not relevant here because they were not designed as tests of the detection model; nor will this model be the focus of any subsequent, full report.

The study and test conditions of interest were designed to lead to little or no remembering. The intention was largely to prevent the encoding of episodes as such. This was achieved by minimizing the possibility of encoding the items in any distinctive way and by maximizing processing fluency, both at study and in the overlap between study and test presentation modes.

To this end, Gregg and Gardiner (1994, Experiment 2) presented a list of words at a very rapid rate in conjunction with a study task that emphasized visual processing, and then at test presented the words in an identical visual format. At study, each word appeared on a screen for 300 msec and there was an interval of 200 msec between each word. A group of 16 subjects was told to count the number of words that contained letters that were blurred and to report the number of these words at the end of the list. It was also emphasized that they should not try to remember what the target words were, only how many there were. In fact, none of the words contained any blurred letters, and subjects so reported. In the test, the words were shown on the same screen, in the same type font, but the test was self-paced and *remember* and *know* responses were measured.

The results of reanalyses of data from these conditions in the Gregg and Gardiner (1994) experiment are summarized in Table 1. As these results show, there was relatively little remembering, and A' estimates for individual subjects were significantly greater (an alpha level of .05 was used for all statistical tests) when derived from overall hit and false alarm rates than when derived from *remember* hit and false alarm rates [$t(15) = 4.50$, $SE = .03$]. For the record, the corresponding estimates of criteria, B''_D, were .32 for overall recognition and .99 for *remember* responses.[1]

The three further replications summarized in Table 1 are taken from similar conditions in two other experi-

Table 1
Proportions of Hits, False Alarms, and A' Estimates From Four Replications of Gregg and Gardiner's (1994, Experiment 2) "Perceptual-Fast" Conditions

Response Proportions	Test Items: Old	Test Items: New	A' Estimates
(1) Remember	.11	.03	.66
Overall	.63	.22	.80
(2) Remember	.12	.04	.67
Overall	.75	.21	.84
(3) Remember	.14	.04	.68
Overall	.65	.22	.80
(4) Remember	.06	.04	.60
Overall	.58	.32	.71

Note—(1) Gregg and Gardiner (1994, Experiment 2); (2) first unpublished experiment; (3) second unpublished experiment, immediate test; (4) second unpublished experiment, 1-week test.

ments that are part of a series of experiments still some way from completion. In the first of these unpublished experiments, the study and test conditions were the same as those in the Gregg and Gardiner (1994) experiment, but there were 12 instead of 16 subjects in the group. The study and test conditions were the same in the second of these experiments, too, except that retention interval was also manipulated. In addition to an immediate test, there was also a test 1 week later. Another group of 12 subjects took both tests, but with alternative sets of studied and unstudied words on each test.

It can be seen that the results from the first unpublished experiment quite closely replicate those of Gregg and Gardiner (1994). A' estimates were again significantly greater when derived from overall hits and false alarms [$t(11) = 5.99$, $SE = .03$]. The corresponding estimates of B''_D were .12 and .98. The immediate test results from the second unpublished experiment also quite closely replicate those of Gregg and Gardiner. A' estimates were significantly greater when derived from overall hits and false alarms [$t(11) = 3.88$, $SE = .03$]. The corresponding estimates of B''_D were .25 and .98. And in the delayed test, there was virtually no remembering at all. Recognition there was almost entirely associated with knowing. A' estimates again differed significantly [$t(11) = 2.29$, $SE = .05$]. The corresponding estimates of B''_D were .20 and .99.

The results, like those in Donaldson's (1996; personal communication, April 11, 1997) meta-analyses, are remarkably consistent. Table 1 summarizes data from a total of 52 individual subjects. In 47 out of 51 cases in which the two A' estimates differed, the estimates were greater for overall recognition than for remembering. Using a normal approximation to the binomial, this trend gives a z score of 5.88. These results show that recognition performance can be based largely, if not wholly, on noetic consciousness at the level of an entire set of individual subject data.

In contrast with the outcome from the meta-analyses, the outcome from the individual subject data summarized in Table 1 is just the same when d' estimates are used. Unlike d', the range of A' is constrained so as to avoid difficulties in calculating estimates with zero false alarm rates. And because of zero scores it was possible to calculate d' estimates based both on overall hit and false alarm rates, and on *remember* hit and false alarm rates, for only 22 individual subjects. The overall d' estimate was 1.20 and the *remember* d' estimate was .40. The overall d' estimates were greater than the *remember* d' estimates for 21 of these 22 subjects. Calculated from the aggregate data summarized in Table 1, d' estimates show a similar difference. Thus our conclusion does not depend on preferring A' estimates or on any differences between A' and d' estimates, especially considering the very low false alarm rates (see Macmillan & Creelman, 1996).

Although having little or no remembering clearly makes it more likely that estimates derived from overall recognition will be greater than those derived from remembering, at least some evidence suggests that similarly reliable differences in the two estimates might sometimes occur under less extreme circumstances. Parkin and Walter (1992) found that elderly adults not only made fewer *remember* responses than young adults, but they also made quite a few more *know* responses (see also Perfect, Williams, & Anderton-Brown, 1995). As Donaldson (1996) pointed out, those findings suggest that similar individual differences in A' estimates might occur in older adults.

And Inoue and Bellezza (in press) found significantly greater overall A' estimates in young adults in other tests of the detection model that included a manipulation of the similarity between study and test contexts. However, those effects were obtained in only two out of four experimental conditions, one in their Experiment 1, which did not entail any manipulation, and the other in Experiment 2, when study and test contexts differed. The two A' estimates were identical when study and test contexts were the same or when the test context was new. The reasons for those effects are therefore obscure, and Inoue and Bellezza (in press) discounted them, partly on the grounds of small effect sizes. But small effect size is to be expected in comparing the proportions of *remember* responses with the proportions of *remember* and *know* responses under most typical experimental conditions.

Also relevant are some findings by Curran, Schacter, Norman, and Galluccio (1997) in a study of a patient with a right frontal lobe infarction. Curran et al. reported overall A' and *remember* A' estimates and commented on the general similarity of these estimates and their consistency with the detection model. They also discussed a discrimination impairment shown by the patient, in comparison with the control group, and one particular experimental condition in which the patient showed a much greater A' for remembering than he did for overall recognition, which, as they pointed out, does not seem consistent with the detection model.

But in fact their data refute the model more decisively than that. Across the four experiments they described, overall A' estimates were greater than *remember* A' estimates in all 10 out of 10 experimental conditions in the control group (see their Tables 1 and 2). In the patient, overall A' estimates were less than *remember* A' estimates in eight out of nine of the same experimental conditions. In the other condition, the two estimates were identical. This is a highly significant difference ($\chi^2 = 8.78$). The reason seems to be that the patient generally made more *know* responses to lures than to targets; hence when his *know* responses were added to his *remember* responses, discriminability decreased.[2] But in the control group, *know* responses always provided an additional basis for discriminating between targets and lures.

What is this additional basis and how, in particular, should we interpret the more dramatic effects summarized in Table 1? In terms of dual-component theories, the interpretations seem straightforward. On Tulving's

(1985) systems theory, for example, the Gregg and Gardiner (1994) procedure is one that allows events to be encoded into semantic memory but not into episodic memory, which requires more conscious elaboration. Thus at test subjects are aware of having encountered the items at study, but have little or no ability to recollect those encounters. Similarly, the procedure is one that largely prevents any distinctive encoding of items, instead emphasizing processing fluency. Thus according to Rajaram's (1996; in press) distinctiveness/fluency model, recognition is based largely on fluency rather than on recollection, which on this model depends on distinctiveness. And the procedure was designed to have exactly these kinds of consequences.

There are other problems for a unitary trace strength model. For example, *remember* and *know* responses do not correspond with judgments of confidence, which on this model should be alternative measures of trace strength. Gardiner and Java (1990) showed that if *sure* and *unsure* judgments are substituted for *remember* and *know* judgments, the pattern of results is quite different (see also Parkin & Walter, 1992; Rajaram, 1993). As Inoue and Bellezza (in press) pointed out, subjects may interpret the alternative labels somewhat differently (e.g., the term *unsure* may encourage guessing), but that does not alter the fact that *remember* and *know* judgments are not equivalent to high- and low-confidence judgments.

Furthermore, remembering and knowing may differ significantly when confidence judgments do not. In their replication of the Parkin and Walter (1992) finding that elderly adults make fewer *remember* and more *know* responses than young adults, Perfect et al. (1995) also measured confidence ratings on a 3-point scale. They found that confidence judgments did not differ significantly with age, and that, if anything, the elderly adults tended to be more confident in their recognition responses than the young adults were.

Other circumstances in which remembering is relatively weak have been described by Conway, Gardiner, Perfect, Anderson, and Cohen (in press) in a study of states of awareness associated with the acquisition of knowledge by psychology undergraduate students. One such finding in this study was that, with multiple-choice questions that tested students' ability to recognize facts learned in research methods courses, good performance was largely associated with knowing, rather than with remembering, although the reverse was true in similar tests of students' knowledge following more conventional lecture courses.

There is also some evidence of significant differences in remembering and knowing between two conditions in the same experiment that yielded identical recognition performance. Donaldson (1996) discussed one example from Dewhurst and Conway's (1994) study of word and picture recognition, though he tended to dismiss the finding because in one of their conditions performance was almost perfect. But Mäntylä (1997, Experiment 3, see Table 4; see also Experiments 1 and 2) obtained just the same outcome in comparing the effects of distinctive and relational encoding on face recognition, and performance in his study does not seem unduly high.

Another, rather different, kind of difficulty for the detection model arises when tests of the model require subjects to use *know* responses very freely. The problem here is that subjects may use *know* responses in ways that do not reflect any awareness of memory (Strack & Forster, 1995). Indeed, with very free responding, *know* responses to new items can exceed *know* responses to old items and give rise to performance that appears to be below chance. This implies that new items are somehow more familiar than old items (see Curran et al., 1997; Donaldson, 1996; Jacoby et al., 1997; Yonelinas, Dobbins, Szymanski, Dhaliwal, and King, 1996), which clearly calls into question the validity of the responses.

Several recent studies have allowed subjects to report guesses as well as make *remember* and *know* responses (Gardiner, Java, & Richardson-Klavehn, 1996; Gardiner, Kaminska, et al., 1996; Gardiner, Richardson-Klavhen, & Ramponi, 1997; see also Mäntylä, 1997). These studies have yielded three important findings with respect to subjects' reported guessing. First, it is *guess* responses, not *know* responses, that sometimes show below-chance performance, presumably in part simply because of greater response opportunity with new than with old items (see Gardiner, Java, & Richardson-Klavehn, 1996; Gardiner, Kaminska, et al., 1996). Second, although the proportion of *guess* responses varies considerably across different experimental conditions in these studies, unlike *know* responses, these *guess* responses do not show any memory for studied items. Not only do guesses to new items sometimes exceed guesses to old items, but guesses to old items never exceed guesses to new items. Guesses to old items do not exceed guesses to new items even in two-alternative, forced-choice tests, which show similar dissociations between remembering and knowing to those found in *yes/no* recognition (see Gardiner, Java, & Richardson-Klavehn, 1996).

And third, it is *guess* responses, not *know* (or *remember*) responses, that have been shown to be affected by manipulations of response bias, as well as by response opportunity, in *yes/no* recognition tests. In Gardiner et al.'s (1997) replication of Strack and Forster's (1995) Experiment 1, one group of subjects was told that only 30% of the test items were targets, and another group was told that 50% of the test items were targets. In fact, the actual proportion of targets was 50% for each group. This manipulation of response bias resulted in increased responding in the group that was told that 50% of the test items were targets, the result Strack and Forster obtained, but it was only the *guess* responses that increased significantly—moreover, only *guess* responses to lures. In contrast, Strack and Forster found a significant increase in *know* but not *remember* responses. Their subjects, however, were not allowed to report guesses.

The problem is that in tests of the detection model in which response criteria are varied and reports of guessing are not allowed, subjects are presented with obviously conflicting task demands. Similarly conflicting task demands, though between remembering and knowing rather than between knowing and guessing, would occur if subjects were instructed to report recollective experiences when making *know* responses (see, e.g., Perfect, Mayes, Downes, & Van Eijk, 1996). As Perfect et al. (1996) have shown, subjects will do this, if given such instructions. But in these circumstances, too, *know* responses are not valid measures of noetic consciousness. Evidence that subjects do not normally report *know* responses that reflect any recollective experiences has been presented by Java, Gregg, and Gardiner (1997) and Gardiner, Ramponi, and Richardson-Klavehn (in press).

Finally, it is a moot point whether the detection model can accommodate physiological evidence for the two states of awareness. Düzel, Yonelinas, Mangun, Heinze, and Tulving (1997) measured event-related potentials (ERPs) while subjects made *remember* and *know* responses in an extended version of the false recognition paradigm that was introduced by Deese (1959) and further developed by Roediger and McDermott (1995). They found that remembering and knowing were associated with quite distinct ERP measures of brain activity. Moreover, those patterns of activity were not sensitive to the old or new status of the item. They were indistinguishable for true and for false (not presented) targets. Thus the subjective states of awareness correlated directly with the measures of brain activity, and not with the item's old or new status. And how, with a detection model, can two quite distinct patterns of brain activity be mapped on to a continuum of trace strength, a continuum that in turn has to map on to two quite distinct kinds of mental experience?

Our conclusion is that both at the level of the meta-analyses of experimental conditions (e.g., Donaldson, 1996) and at the level of individual subject data, the most important prediction of the detection model lacks convincing support. In the meta-analyses, A' estimates of discriminability consistently tend to be greater for remembering and knowing than for remembering alone, and our findings show they can be very much greater in individual subject data. There are other findings that the detection model cannot accommodate and that present difficulties even for hybrid models that make use of *remember* and *know* responses to distinguish between recollection conceived as a threshold process and familiarity as a detection process (see Yonelinas et al., 1996). All these findings support theories that assume that knowing reflects an additional source of memory, not merely a more lenient response criterion.

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NOTES

1. A' estimates normally vary between .5, which represents chance, and 1. They are given by the formula

$$A' = \frac{1}{2} + \frac{(\text{HIT}-\text{FA})(1+\text{HIT}-\text{FA})}{4\text{HIT}(1-\text{FA})}.$$

In some of the remembering data here there are hit rates of zero and cases where performance is below chance (e.g., if a subject made one or two *remember* false alarms and had no *remember* hits). In such cases, we have arbitrarily assigned A' estimates of .5, which of course is conservative in that it tends to work against the hypothesis. The corresponding estimates of criteria, B''_D, normally vary between +1 and −1, with lower and negative values representing more liberal responding. They are given by the formula

$$B''_D = \frac{(1-\text{HIT})(1-\text{FA}) - (\text{HIT})(\text{FA})}{(1-\text{HIT})(1-\text{FA}) + (\text{HIT})(\text{FA})}.$$

2. Indeed, in the condition that Curran et al. (1997) discussed, the patients' *know* false alarm rate approximated 50%, compared with a hit rate of about 5% (see their Figure 5).

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